Razor diode is being smaller than for PTW SRS 60018 diode. PDDs agreed well for both diodes for the measured cones. The tale of the profile for 60 mm cone at 30 cm depth is being overestimated by approximately 10% for both detectors compared to the profiles measured with PTW 31010 ionization chamber. The dose per pulse dependence for IBA Razor diode is larger than for PTW SRS 60018 diode.

Conclusion: Both detectors are suitable for commissioning of Cyberknife M6 system. Correction factor required for 5 mm cone for IBA Razor diode is larger than for it predecessor – IBA SFD diode (as based on published data). Both detectors require correction factors in order to account for the overestimation of the signal. Because of lower sensitivity the time required to collect the same quality data with IBA Razor diode is about 3 times greater than for PTW SRS 60018.

EP-1506

Investigation of PTW's "microDiamond" detector for dosimetry in small animal radiotherapy research

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Purpose or Objective: The recently presented single crystal diamond detector (SCDD) from PTW (PTW-Freiburg, Germany) called microDiamond (µD, type TM60019) is especially meant to be used in small field dosimetry. As irradiation experiments of small animals in preclinical settings often use small fields this µD detector could potentially be the right device in this special field of interest.

Material and Methods: Two different kinds of measurements were performed: a) horizontal and vertical beam profiles, and b) depth dose curves. Both types of measurements were done in solid water slabs for two field sizes: 5x5 mm^2 and 10x10 mm^2. Measurement a) was done in 2 cm depth with the detector in the isocenter. The orientation of the detector was perpendicular to the beam axis and in terms of rotation in a suitable position to prevent effects due to unequal sensitivity. Measurement b) was performed with a fixed SSD of 304 mm and in depths in the range from 0 to 51 mm. The detector's axis was parallel to the beam axis during this measurement. To enable the comparison of our measured depth dose, the µD detector was calibrated for our distinct setup against a standard ionization chamber in a large field. We compared the results of the µD detector to film measurements with radiochromic films (Gafchromic EBT3, Ashland, USA).

Results: The results of the beam profile measurements with the µD detector of the 10x10 mm^2 field are 10.10 mm in horizontal and 10.16 mm in vertical direction for the field width at half maximum (FWHM). For the 5x5 mm^2 field the µD results are 5.08 mm in both directions. The measured depth dose curve shows values from 4.05 Gy/min in a depth of 1 mm and 3.71 Gy/min in 5 mm down to 1.14 Gy/min in 51 mm. In comparison, the field size measurements with the film resulted in 10.16 mm (5.19 mm) for horizontal and 10.20 mm (5.20 mm) for vertical direction for the 10x10 mm^2 (5x5 mm^2) field. This means a very good agreement in the 10x10 mm^2 field (difference less than 0.1 mm or 1%). In the 5x5 mm^2 field, the differences between film and µD is 0.11 mm and 0.12 mm (less than 2.4%). Depth dose curve measurements show also very good agreement of the two methods. In a depth of 5.3 mm the film measurements produced 3.68 Gy/min, in 51.4 mm depth 1.16 Gy/min (maximum deviation of about 2 %).

Conclusion: We showed measurements with the µD detector of two very important variables of radiation fields and their comparison to reference measurements with radiochromic film. As the discrepancy between both methods is very small, these findings justify the usage of the described µD detector for quality assurance measurements in preclinical research, especially for the SARRP.

EP-1507

Which detector for small photon field measurements?

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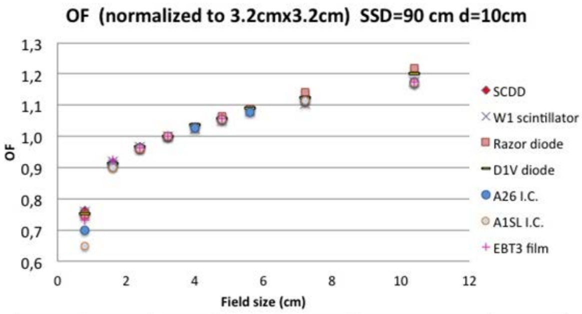
Purpose or Objective: Dosimetry in small fields is an open issue, due to several sources of errors, reported in literature. The purpose of this work is to compare the response of different detectors for the measurements of output factors (OF), profiles and percentage depth dose (PDD) curves for Elekta Synergy S BM 6MVRX beams and field sizes from standard (10.4cmx10.4cm) down to 0.8cmx0.8cm.

Material and Methods: We tested the detectors reported in the first table.

tested detectors	volume (mm3)	diameter (mm)	thickness (mm)	☺	☹	μ_{en}/ρ (cm^2/g)	ρ (g/cm^3)
Single crystal diamond detector (SCDD)	0.004	2.2	0.001	small thickness, mass energy absorption coefficient similar to water	2mm diameter active area => volume averaging effetcs => under response, high density => overresponse in small fields	☺	3.5
Exradin W1 plastic scintillator	2.4	1	3	very good water equiv.	instable, not user friendly	☺	1.05
Iba Razor diode	0.01	0.6	0.02	small active volume	overresponse to low energy	☹	~2.3
Exradin D1V diode	0.05	1.1	0.05	small active volume	overresponse to low energy	☹	~2.3
Exradin A26 ion chamber	15	3.3			volume averaging effects	☺	
Exradin A1SL ion chamber	57				volume averaging effects	☺	
Film gafchromic EBT3			0.28	good water equiv. And spatial resolution	noise	☺	

No corrections were made for the difference between detectors and water (fluence perturbation and non water-equivalence) neither for volume averaging effects.

Results: OF were referred to 3.2cm field and deviations calculated respect to W1 as reference detector, both for its smaller dimensions and its better water equivalence.



field size (cm)	diamond SCDD	scintillator W1	diodes Razor	diodes D1V	ion chambers A1SL	ion chambers A26	film gafchromic
10,40	-0,5%	0,0%	3,8%	2,3%	-0,4%	-0,1%	-0,1%
7,20	0,6%	0,0%	3,3%	1,9%	0,9%	0,9%	
5,60		0,0%	0,9%	1,0%		-0,3%	
4,80	0,4%	0,0%	1,3%	0,7%	0,2%	0,5%	0,6%
4,00		0,0%	0,6%	1,2%		0,4%	
3,20	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2,40	-0,1%	0,0%	-0,7%	0,0%	-0,6%	-0,4%	-0,5%
1,60	-0,1%	0,0%	-1,4%	-0,7%	-2,0%	-1,3%	0,6%
0,80	0,6%	0,0%	-1,1%	-0,9%	-14,3%	-8,0%	-3,5%

For large fields all detectors agree within 1% except for diodes, which show an over response for large fields, due to low energy scattered radiation. SCDD is in agreement with W1 within 0.6% for all field sizes, also down to 0.8cm, maybe for compensation effects between the over response due to high density and the under response due to volume averaging effects. For 1.6cm and 0.8cm, ion chambers show an under

response up to 14% A1SL and 8% A26 (volume averaging effects), D1V diode is in agreement with W1 within 1%, while Razor diode shows a more pronounced under response presumably due to the enclosure, given its smaller dimensions respect to D1V. Film shows a deviation of -3.5% for 0.8cm field, due to the sampling area, limited inferiorly by noise.
As for PDDs, A26 can be trusted as reference detector for 10.4cm field (no volume averaging effects). Razor diode shows an over response up to 3% at 20cm depth respect to A26 (low energy scattered radiation). Also W1 shows an over response, up to 4% at 20cm depth, respect to A26.
For field sizes under 2cm, volume averaging effects should be considered, especially for ionization chambers, in function of depth. PDD at large depth could in some case be overestimated if large volume effects occur. In this case W1 could be taken as reference, for its small active area and water equivalence. Razor shows a slight over response (within 1%), probably due to low energy scattered radiation, while A26 shows an over response, maybe due to volume averaging effects, up to 3%.
Profiles obtained with Synergy S BM have a minimum penumbra of some mm, so are well represented by all detectors with diameter of the active area inferior or equal to 1mm.

Conclusion: For small filed sizes (< 3cm) it is still not possible to identify a reference detector, with an optimal behaviour. For 6MVRX beams by SynergyS BM and field sizes down to 1cmx1cm, SCDD seems to offer the best compromise, since compensation between opposite effects (volume averaging and density) occurs, which allows to avoid corrections. For smaller fields, steeper penumbras or better accuracy, corrections for the above mentioned effects should be applied and detector should be used perpendicular to beam axis for penumbra sampling.

EP-1508

Multicenter study of FFF beams with a new stereotactic diode: can be defined a universal OF curve?

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Purpose or Objective: The use of flattering filter free (FFF) beams are increasing in stereotactic body radiation therapy (SBRT) due to the reduction in delivery time. Small radiation fields (<30mm) are typically involved in SBRT procedures. In small fields, the measurements of the output factor is subject to large uncertainties, impacting in the effective delivered dose to the patient. Dose output ratios (DORs), defined as the ratio of detector readings without correction factor (Alfonso et al., Med Phys 2008), were evaluated in several different centers and an eventual mathematical description of the DORs curve was investigated.

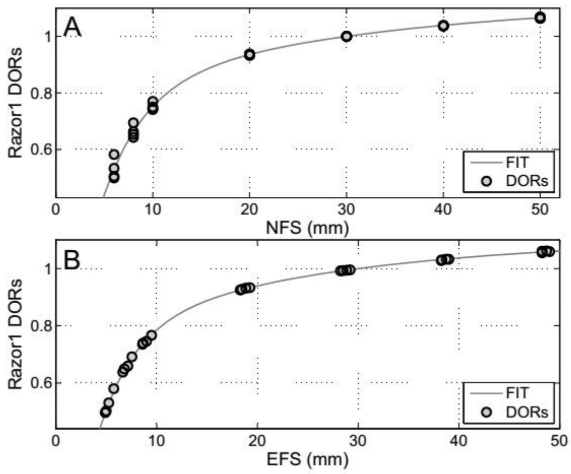
Material and Methods: A couple of new unshielded stereotactic diodes (Razor, IBA) was tested under 7 different TrueBeams using high dose rate (2400 MU/min) 10MV FFF beams. Small fields ranging from 6 to 50 mm were analyzed in terms of profiles and central axis point measurements. DORs were normalized to 30 mm field and were calculated as a function of nominal (NFS) and effective (EFS) field size. From DORs acquired using Razor1 (4 centers), a theoretical equation was extrapolated by means of a double exponential fit. The 3 centers with Razor2 were used to test the mathematical relationship.

Results: Penumbra, field width (defined as FWHM) and EFS analysis over the 7 Truebeams were reported in **Table 1**. The EFS were systematically smaller than NFS (p<0.01) for all field size range, with mean difference of 0.9±0.5 mm. The DORs fits using the NFS and EFS had, respectively, R2=0.993 and R2>>0.999 (**Figure 1**). The test mean deviations from predicted DORs, using NFS and EFS fits, were 2.9% and 0.7%, respectively, for field size ranging between 6 and 20 mm. The maximum deviations were 6.1% (6mm field size) for NFS and <2% for EFS.

Table 1. . Penumbra, field width and EFS analysis in term of mean, standard deviation and relative percentage errors for all 7 Truebeams.

NFS (mm)		Penumbra width (mm)	FWHM (mm)	Penumbra width (mm)	FWHM (mm)	EFS (mm)
		Cross-line		In-line		
6.0	Mean (St Dev)	2.0 (0.1)	5.3 (0.2)	2.6 (0.2)	5.6 (0.6)	5.4 (0.4)
	Relative Error (%)	3.7	4.3	6.3	10.8	7.0
8.0	Mean (St Dev)	2.2 (0.1)	7.2 (0.2)	2.9 (0.2)	7.4 (0.6)	7.3 (0.4)
	Relative Error (%)	3.4	3.4	5.7	8.6	5.6
10.0	Mean (St Dev)	2.4 (0.1)	9.1 (0.3)	3.1 (0.1)	9.2 (0.7)	9.2 (0.4)
	Relative Error (%)	3.3	2.9	4.7	7.1	4.7
20.0	Mean (St Dev)	3.0 (0.1)	19.0 (0.3)	3.8 (0.2)	18.9 (0.6)	18.9 (0.4)
	Relative Error (%)	2.9	1.7	4.8	3.3	2.2
30.0	Mean (St Dev)	3.4 (0.1)	29.1 (0.4)	4.3 (0.1)	28.8 (0.6)	28.9 (0.4)
	Relative Error (%)	3.5	1.3	2.4	2	1.5
40.0	Mean (St Dev)	3.8 (0.1)	39.0 (0.5)	4.6 (0.1)	38.7 (0.6)	38.8 (0.5)
	Relative Error (%)	2.1	1.3	3.2	1.6	1.3
50.0	Mean (St Dev)	4.1 (0.1)	49.0 (0.4)	5.0 (0.1)	48.8 (0.7)	48.9 (0.5)
	Relative Error (%)	3.3	0.9	2.2	1.4	1.0

Figure 1. Razor1 DORs plotted as a function of NFS (A) and EFS (B) with relative mathematical curve.



Conclusion: EFS measurements were confirmed to be mandatory when comparing DORs over different centers. A "gold standard" curve was tested and found suitable for DORs calculation using the new Razor diode for TrueBeam 10 MV FFF beams.

EP-1509

Small fields Output Factor measurement using several multidetectors arrays

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Purpose or Objective: The aim of this study was to determine and compare small fields Output Factor (OF) measure with different types of multidetector arrays. OF measurements were performed on a CyberKnife® System.

Material and Methods: OF were measured using multidetector arrays: PTW OCTAVIUS Detector 1500, PTW OCTAVIUS Detector 1000 SRS and SunNuclear SRS Profiler.